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Main Theme

"Designing the Future: Changing Paradigms and Transhumanism with Artificial Intelligence in Education"

Sub-Themes

- Academic freedom, autonomy, and social responsibility in education
- Artificial intelligence and educational applications
- Augmented reality applications
- Barriers to learning
- Blended learning
- Computer-assisted measurement and evaluation
- Core skill sets for students and teachers
- Design of school buildings in the future
- Designing and delivering a digital strategy
- Digital competence
- Digital parenting
- Distance Education
- Earthquake Education
- Post Earthquake Trauma Training
- Earthquake and Effective Psychosocial Intervention Methods
- Earthquake and Trauma
- The Impact of Earthquakes on School Staff
- Education and society
- Education for healthy living and healthy communities
- Education for a sustainable life
- Education in the digital age: Primary, secondary, high school, higher education, and application examples
- Educational leadership in the digital age
- Effects of regional differences on education
- Equity, Diversity, and Inclusion Related to Marginalized Groups
- Emergency Management at Schools
- Evidence-Based School Counseling Services for Refugees and Marginalized Groups
- Globalisation and Education
- Higher education
- Innovative learning designs for student success
- Instructional technologies in the digital age
- Integration of immigrants into education
- K-12 education (preschool, primary, and secondary education)
- Learning management systems
- Lifelong learning
- Machine learning
- Management information system
- Managing schools
- Measurement and evaluation of students' learning outcomes
- Metaverse
- Migration and education
- Multicultural Classroom Concerns of Educators and Parents
- New educational system after COVID-19
- New skills to live and work in new times
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Author Information

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CONTENTS

The Process of Constructing the Concept of Similarity in a Concrete Manipulative-Supported Environment in 8th-Grade

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Abstract

Similarity is a crucial concept introduced in the 8th grade, and it is further developed and reinforced through associations during high school. This research aims to investigate how 8th grade students construct the concept of similarity using concrete manipulative support within the framework of APOS theory. The research was conducted as a qualitative case study and the learning environment was supported by a concrete manipulative (pantograph), A readiness test was administered to 15 students from a central public school in the Black Sea region to assess their prior knowledge of topics related to similarity. Based on the results, four participants with varying levels of understanding were selected. Data collected from the test, observations, and individual interviews were analyzed through content analysis. Findings indicate that the participants could construct the concept of similarity in a concrete manipulative-supported environment (pantograph) efficiently and meaningfully. The results show that all participants internalized the process by constructing similar polygons with the pantograph and understood that the corresponding side lengths of polygons with equal angles have the same ratio. However, while most participants reached the object stage, the participant with the lower intermediated level struggled to coordinate concepts like ratio, angle, and measurement, making it difficult for him to encapsulate the concept and reach the object stage.

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Key Words: *Similarity, Concept formation, Abstraction, APOS Theory, Concrete manipulative, 8th grade students*

Introduction

The concept of similarity, broadly defined as the proportional equality of the dimensions of two or more objects, is crucial in identifying and analyzing relationships between objects and their attributes and developing proportional reasoning skills. Building the foundation necessary for studying more advanced geometry concepts becomes difficult without a proper understanding of similarity. As such, similarity is introduced in the 8th grade and further developed in high school curricula through deeper connections and applications. Mathematics curricula emphasize designing environments where students engage in hands-on learning, using concrete models to symbolize abstract concepts (MEB, 2018a; MEB, 2018b; NCTM, 2000).

However, national and international assessments reveal that students' performance in geometry, particularly in similarity, is below expectations. Research highlights misconceptions related to geometric concepts and underscores the importance of designing alternative and effective teaching environments. Challenges in geometry include teachers' using traditional materials and students' tendency towards rote learning in problem-solving (Toptaş, 2008). Literature highlights common misconceptions about geometric concepts and the need for effective, alternative teaching methods (Carbonneau et al., 2013; D'angelo and Iliev, 2012; Durmus and Karakirik, 2006). Concrete manipulatives aid in teaching and learning mathematics (Çetin et al., 2019; Nishida, 2007; Olkun, 2003). Active manipulation of abstract concepts helps students develop mental imagery, underscoring the importance of manipulatives for understanding and success in mathematics (Moyer, 2001; Suydam, 1986).

Correct and meaningful formation of the concept of similarity is critical for preventing misconceptions and overcoming learning barriers. The abstraction process, involving new experiences and cognitive conflicts, plays a central role in this formation (Chihara, 1963; Skiff, 1953; Von Glasersfeld, 1991). Through abstraction, relationships between mathematical objects are identified, and common properties are translated into simplified expressions. The APOS Theory, which builds upon Piaget's reflective abstraction, offers a framework for understanding how mathematical concepts are constructed in the mind (Arnon et al., 2014; Dubinsky & McDonald, 2001). It models mental construction with Action, Process, Object, and Schema and analyzes how these structures relate through interiorization, coordination, reversal, generalization, and encapsulation mechanisms.

The theory describes the action as transforming pre-constructed objects with external stimuli. This stage involves explicit, guided steps that are later internalized into a process. Repeated actions and reflection transition them into a process where they can be integrated with others. A process can be encapsulated to form objects or coordinated with another process to construct a new one. Recognizing these transformations as affecting a whole makes the process a cognitive object (Asiala et al., 1996; Dubinsky, 1991; Yilmaz, 2023).

The genetic decomposition within the APOS framework identifies the mental structures and mechanisms required for learning a mathematical concept. This model remains a

hypothesis until validated through empirical testing (Arnon et al., 2014).

Research has shown the design of instructional environments for teaching similarity concepts, including the 5E model (e.g., Yörük, 2018), interest in mathematical language use (e.g., Uyen et al., 2021), and ethnomathematics (e.g., Shahbari and Daher, 2020). However, these studies, being quantitative, often lack process evaluations and about their effects on students' academic success (e.g., Göçmen, 2022).

This study's unique contribution lies in its detailed analysis of how similarity as an abstract mathematical concept can be effectively taught using concrete manipulatives such as pantographs. The findings offer valuable insights for improving the teaching of similarity and related concepts while supporting students' cognitive, affective, and psychomotor development.

Hence, this study focuses on the research question: *"How do 8th grade students construct the concept of similarity in a concrete manipulative-supported environment?"*

Method

Research Design

The research was qualitatively conducted to examine 8th grade students' process of constructing the concept of similarity in a concrete manipulative-supported environment within the APOS theoretical framework. Since the in-depth investigation of students' abstraction processes supported by pantographs was a key focus, the research was designed as a case study (Yıldırım & Şimşek, 2021).

Participants

The study involved 15 8th grade students from a central state school in the Black Sea region. Criterion sampling was used to select the class based on heterogeneous academic achievement and interaction and well-expression abilities. Maximum variation sampling determined four participants with different readiness levels (advanced, intermediate, and lower-intermediate) based on test results, teacher opinions, and observations. Individual interviews were conducted with these participants (Yıldırım & Şimşek, 2021). Participant details are in Table 1.

Tablo 1
Participants

Participants	Correct answers	Incorrect answers	Levels
P1	15	3	Advanced
P2	13	5	Advanced
P3	10	8	Intermediated
P4	6	12	Lower-intermediated

Data Collection Tools and Instructional Process

This study employed a readiness test, observations, and individual interviews for data collection, supplemented by activity sheets and individual worksheets. A 19-item readiness test, covering concepts deemed prerequisites for similarity, was developed with input from two mathematics teachers and a mathematics education expert, ensuring validity and reliability. The test, with eight open-ended and eleven multiple-choice questions on ratio, measurement, and geometric concepts, was used to categorize students into four heterogeneous groups and select participants, analyzing their pre-existing knowledge as needed.

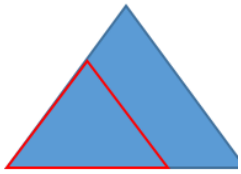
The researcher conducted unstructured observations, recording students' thoughts, actions, and peer discussions using audio and video equipment. A semi-structured interview form, refined with expert feedback, guided individual interviews with volunteers, capturing their responses and reflections. Pantographs were used as concrete manipulatives in real-life scenario activities, aligned with the Ministry of National Education (MEB) curriculum on similarity. These activities, supported by homework and interviews, aimed to enhance discussions and concept formation.

The activities provided to students are as follows:

Key Activity: *Each group receives a model key identical to the others. Students are asked to imagine they are locksmiths and figure out how to duplicate the key. Students replicate the key and compare the scaled versions within and between groups using pantographs of different scales.*

Trojan Horse Activity: *Students are told that a student visiting Çanakkale bought a keychain resembling the Trojan Horse. They are then asked to consider how the keychain compares to the Trojan Horse. Students receive a picture of the Trojan Horse and use pantographs to create keychain models. They compare and discuss their models against the provided image.*

Tile Activity: *Students are informed that a friend wants to create tile models for a bathroom floor using enlarged shapes from a geometric ruler. They are given geometric rulers and pantographs to help. Students compare and discuss their drawings and scaling.*



Plot Activity: *Students learn that two brothers divided a triangular plot with a red wire into two equal parts. They use rulers and protractors to compare and discuss the resulting triangles' side lengths and angles and their perimeter by proportioning.*

Rectangle Activity: *Students receive a rectangle drawn on grid paper, measuring 30 cm by 18 cm. They are tasked with drawing different rectangles fitting within it, with integer side lengths, and discussing the number of possible rectangles.*

Data Analysis

Data from the research were analyzed using content analysis. Data were coded within the APOS theoretical framework to examine students' processes of forming the concept of similarity. Preliminary genetic decomposition, conducted before the application, provided insights into how students might construct these concepts, guiding the design of activities and instructional planning.

According to the preliminary genetic decomposition, the initial object, such as a key or Trojan Horse image, is scaled using pantographs in the action stage, allowing students to draw similar shapes. Students internalize that all new shapes from the original are similar and move to the process stage. They then apply this reasoning to mathematical polygons, noting that corresponding angles are equal, interior angles are unchanged, and side length ratios are consistent. This facilitates coordination with measurement, ratio, proportion, angle, and division concepts. Recognizing that a ratio of 1 relates to congruence, students encapsulate that two polygons are similar if their corresponding angles are equal and side lengths proportional, thus progressing to the object stage. of similarity. When various actions are applied to this information, the concept of similarity as an object is constructed.

Findings

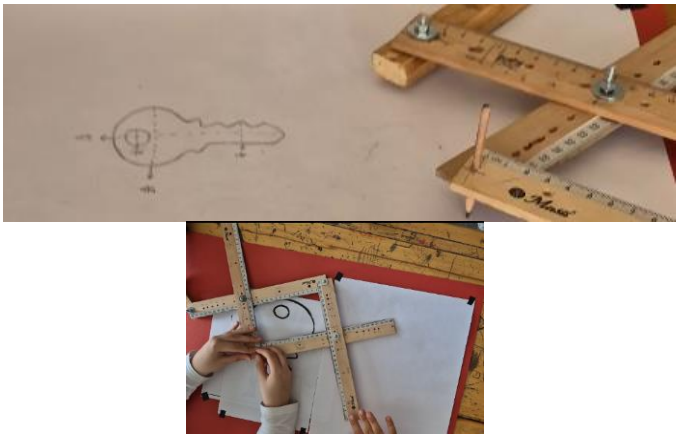
This section examines how students developed the concept of similarity in a pantograph-supported environment using genetic decomposition based on APOS theory. Individual interviews captured reflections on activities and clarified misunderstandings from group work, enabling participants to address gaps in their understanding. Detailed findings for each participant's group and interview are presented below.

1. Findings for P1

P1, with an advanced level, was initially surprised by the results when drawing key shapes at different scales. She noted, *"Oh… a smaller version appeared, how did that happen?"*. Figure 1 shows P1's group activity and measurements.

Figure 1

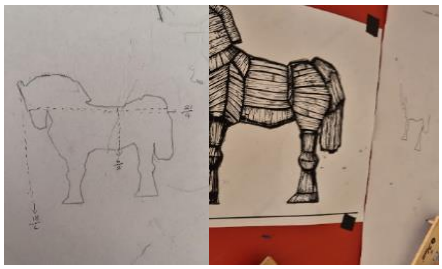
P1's Key Activity Drawing and Measurements with Group



During the Trojan Horse activity, P1 initially struggled with pantograph switching, noting *"The drawings did not match; we had previously drawn a similar key correctly."* After restarting, she observed a value of 18/6 and said, *"The others will also have the same ratio of 3."* And explained, *"We drew the same shape, just smaller, as the pantograph is for this purpose. Previously, the results were the same."* Figure 2 illustrates P1's initial and corrected drawings with ratio results.

Figure 2

P1's Trojan Horse Activity Drawing and Measurements with Group



P1 realized that pantograph-drawn shapes should resemble the original but vary proportionally. In the tiling activity, P1 observed and expressed, *"We can draw both smaller and larger versions."* This indicates the action stage with real-life materials being similar in terms of height and width. In the interview, she explained (R: Researcher):

> P1: *I predicted the ratios of height and width of the Trojan Horse would be the same.*
>
> R: *Why did you think that?*
>
> P1: *Because with the pantograph, we draw the smaller similar shape. The pantograph does that.*
>
> R: *What did this make you think afterward?*
>
> P1: *The shapes are exactly the same, just scaled, but both height and width ratios are the same,*

which is interesting. But I measured each part with a ruler. Otherwise, it might not match.

P1's anticipation of proportional shapes during the Trojan Horse activity indicates progress in understanding. P1 further explained:

R: *What did you think about the tile activity?*

P1: *We were surprised to see that we could draw both smaller and larger versions. We found ratios like 3, not just smaller ones like 2/5. We found the interior angles and their sum to be the same. Although the side lengths differed, they were proportional. We drew a shape three times larger. The pantograph scales polygons proportionally.*

R: *How did you scale the lengths?*

P1: *I compared the short and long sides like in previous activities.*

R: *Is there a relationship between side lengths and angles?*

P1: *They are similar; only the side lengths change proportionally. For example, the side opposite a 100° angle was 12 cm, and the long side was opposite a 100° angle. The short side was opposite an 80° angle.*

R: *What do you compare when scaling angles?*

P1: *I compare the ratios of sides opposite the same angles, like 100° to 80°. This results in the same ratios and shapes.*

Realizing that similar polygons maintain consistent interior angles but have proportional side lengths shows P1's progress to the process stage. P1 coordinated this understanding with processes of ratio, proportion, and angles:

P1: *I did not struggle much with the plot activity. I understood that the lengths of sides opposite the same angles were in a 2:1 ratio, meaning the polygons were 2 times similar.*

R: *How did you understand this?*

P1*: The sides opposite the same angles were always double, so 8.5 units measured became 17 units. Both were opposite 90° angles.*

R: *How did you interpret the relationship between perimeters?*

P1*: We added up the side lengths unnecessarily; since each side was doubled, the perimeters were also doubled, which I initially did not realize.*

P1 developed an understanding of polygon similarity, recognizing that polygons are similar if corresponding angles are equal and corresponding sides are proportional. She noted that the similarity ratio equals the perimeter ratio. Figure 3 shows her work on the rectangle activity by increasing side lengths by 5 and 3 units.

Figure 3

P1's Rectangle Activity Work

P1 explained her thoughts during the interview:

R**:** *After finding the ratio of the long to short sides, how did you proceed?*

P1: *I created new rectangles by increasing the long side by 5 units and the short side by 3 units.*

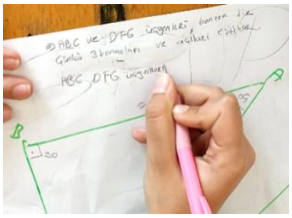
R: *How did you come up with this method?*

P1*: I figured out the enlargement process by adding rather than multiplying.*

By measuring the angles and side lengths of given polygons and comparing them to determine similarity ratios, P1 demonstrated the encapsulation stage. She coordinated with concepts of proportion, division, angle, equal angles, and measurement. Her actions on the given rectangle as object show her meaningful construction of the similarity concept (Figure 4).

Figure 4

P1's Action Work on Object



Thus, it can be said that her thinking supported the preliminary genetic decomposition.

2. Findings for P2

P2 with advanced level, remarked during a group activity that the key being formed would have equal length and width, resembling a square. This may stem from generalizing the relationship between side lengths to a square. During the interview, P2 explained her reasoning as follows:

R: *What do you think about the Trojan horse that will be formed?*

P2: *I believe the length-to-width ratio will be the same again. I don't need to measure all the sides because the ratio of the lengths and widths will be equal. In the key activity, the ratio turned out the same.*
R: *What did you realize in both activities?*

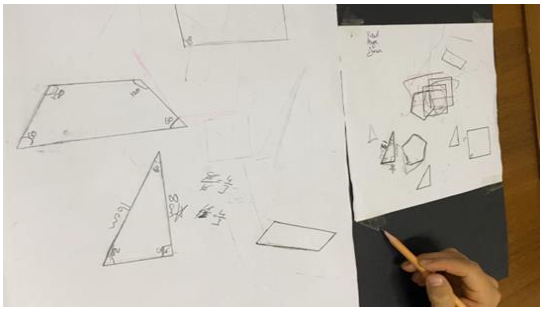
P2*: We are drawing similar things, but the size depends on the pantograph scale.*

By using the pantograph, P2 demonstrates the ability to create similar objects. Although she does not formally

describe the constant ratio, she understands the concept. In Figure 5, P2 demonstrated the side and angle relationship in triangles formed with a geometry ruler.

Figure 5

P2's Polygon Drawing Work



During the interview, P2 further clarified:

> R: *How did you calculate the ratios of the lengths?*
>
> P2: *I compared the lengths of sides with the same angles.*
>
> R: *Do you think there is a relationship between side lengths and angles?*
>
> P2*: For example, in the larger triangle, the side opposite the 30^o angle is 8 cm, and the side opposite the 60^o angle is 16 cm, giving a ratio of 1/2. The same ratio was found in the shape we created.*
>
> *In the shape we created, when we divided the sides opposite the same angles, the ratio was also 1/2.*
>
> R: *What did you infer?*
>
> P2: *Dividing the sides opposite the same angles gives the same result. So, both the side and the shape are similar.*

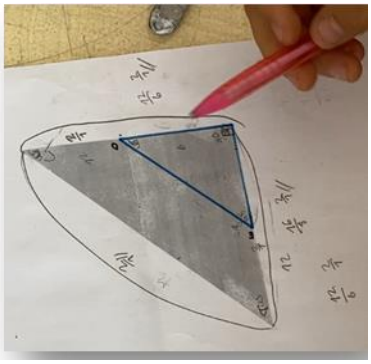
P2's awareness of drawing polygons with various similarity ratios suggests that she has internalized the process. Her realization that similar polygons have unchanged interior angles, with a constant ratio between corresponding side lengths, can also be inferred from the following conversation:

> R: *What did you think about during the plot activity?*
>
> P2: *I compared the lengths of the sides opposite the same angles, ensuring the angles matched. Once I found the ratio of the longest sides, I knew the others would also be the same since the ratio remained constant at 1/2. The triangles are twice as large, so dividing the side lengths by two gives the same ratio. Similar shapes result from this consistency.*
>
> R: *What did you think about the perimeter?*
>
> P2: *Since each side length doubled, I predicted the perimeter would also double, as the perimeter is the sum of the sides. And it did.*

In Figure 6, P2's work on the plot activity is displayed.

Figure 6

P2's Plot Activity Wor

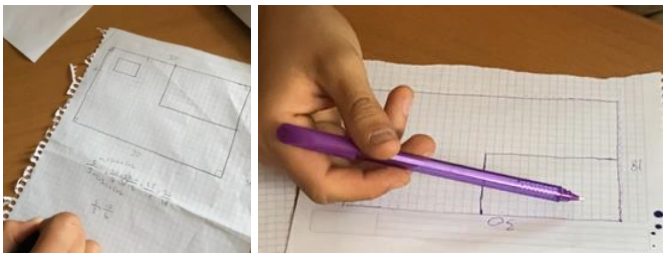


P2 coordinated angles and proportions during the process. Her ability to construct the conditions for forming similar polygons, as well as her recognition of a constant similarity ratio, indicates progression toward the encapsulation. Furthermore, she is able to deduce that the ratio of similarity would also apply to the perimeters of the polygons.

In the rectangle activity, P2 used half the shape, suggesting a reflection of rational numbers used in the comparisons. In Figure 7, P2's initial shape and similarity ratio calculations are shown.

Figure 7

P2's Rectangle Activity Work



During the interview, P2 explained her reasoning:

> R: *What did you think about the rectangle activity?*
>
> P2: *First, I divided the long side by the short side. To create similar rectangles, I divided the sides each time, reducing 30/18 to 5/3. I thought that the ratio should remain constant, and the rectangles should scale proportionally.*
>
> R: *Why did you ensure the ratio stayed the same?*
>
> P2: *Because if I'm creating a similar rectangle, the same constant ratio should appear when*

dividing the sides, making it seem like I'm enlarging it proportionally.

By measuring and comparing the angles and side lengths of the polygons, P2 calculated similarity ratios to determine if they were similar. This coordination of ratio, proportion, division, equal angles, and measurement demonstrates progress toward encapsulation. Creating rectangles with the appropriate similarity ratio indicates that she has reached the object stage.

3. Findings for P3

It is observed that P3, with an intermediated level, has moved into the action stage and internalized the concept of creating similar shapes at different scales using the pantograph:

P3: *Previously, we found a smaller ratio like 2/5, but now we found a larger ratio, like 3.*

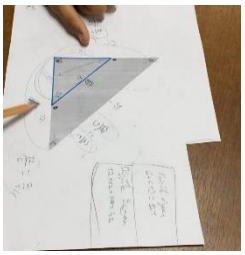
R: *What did this make you think?*

P3: *I realized that I could use the pantograph to draw similar shapes at different ratios.*

Figure 8 shows the square and angle-side measurement results P3 obtained during the tile activity.

Figure 8

P3's Tile Activity Work



During the process, P3 noticed that the interior angles of similar polygons remain unchanged, but only later understood that sides opposite equal angles create the similarity ratio. Coordinating the angle concept was challenging. He explained in the interview:

R: *What did you think during the tile activity?*

P3: *I chose a square and found its angles to be 90°. The other square had the same angles. The ratio of side lengths was 12/4, or 3, using the pantograph.*

R: *How did you relate angles to side lengths?*

P3: *Both shapes had the same interior angles, but the side lengths were three times each other.*

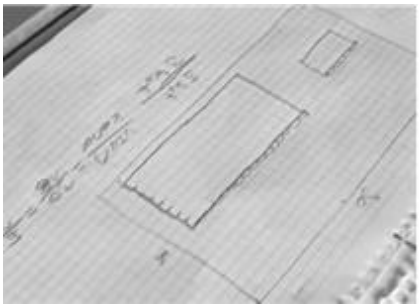
R: *Which sides did you compare between the two squares?*

P3: *It doesn't matter; they are all three times each other.*

Figure 9 shows P3's plot activity work.

Figure 9

P3's Plot Activity Work



He explained his thoughts:

R: *How did you perform the plot activity?*

P3: *I first compared the longest sides and realized I was dividing sides opposite equal angles. The ratio of sides opposite the 90° angles was 2/1. Then, when the angles were 45°, I divided the sides opposite these angles as well. This way, we get similar shapes.*

During the plot activity, he coordinated the angle concept, leading to the understanding that polygons are similar if corresponding sides opposite equal angles are proportional. Figure 10 shows P3's work on creating similar rectangles.

Figure 10

P3's Rectangle Activity Work

P3 found a similarity ratio of 5/3, then drew a rectangle twice the size (60/36) but noted it would exceed the original rectangle's boundaries:

R: *What did you think about the rectangle problem?*

P3: *I realized the interior angles would be the same, 90°. I divided the long side by the short side to create similar rectangles and simplified it to 5/3. After that, I expanded it.*

He coordinated concepts of ratio, proportion, division, equal angles, and measurement to create rectangles with a 5/3 similarity ratio, advancing toward encapsulating the object.

4. Findings for P4

P4, with a lower-intermediated level, generalized excessively in the Trojan Horse activity by stating, *"I think this will have the same ratio as the key."* P4 assumed all pantographs have

the same similarity ratio, but later realized this assumption was incorrect. It appears she demonstrated the action stage by drawing similar shapes at specific scales using a pantograph. She explained:

> R: *What ratio did you find for the Trojan Horse?*
>
> P4: *I think it will be 1/4, like the key.*
>
> R: *Why?*
>
> P4: *Because we changed the pantographs, but don't they all create the same ratio?*

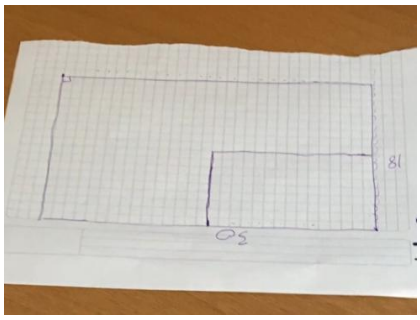
P4 struggled to predict that different ratios of similar shapes could be drawn with the pantograph and had difficulty internalizing and advancing to the process stage. She found it challenging to simplify the height ratio, which delayed recognizing the relationship between the two objects compared to other students. Later, P4 stated, *"The simplest form for both is 2/5,"* and explained their thoughts during the tile activity:

> P4: *I was very confused. I didn't understand.*
>
> R: *Why?*
>
> P4: *It was hard to draw, and I wondered why we needed to find angles. Wouldn't comparing side lengths be enough? The angles were the same.*
>
> R: *Which sides did you compare?*
>
> P4: *I divided the short and long sides facing the same direction.*

P4 struggled to coordinate with angles and did not understand that sides opposite equal angles must be proportional. Figure 11 shows P4's polygon drawing.

Figure 11

P4's Polygon Drawing



P4, in the plot activity, found a ratio of 2/1 for sides opposite 90°. She suggested that other angles should match those in a small triangle. She also found a 2/1 ratio for side lengths and stated that the perimeter would double. Due to difficulties in coordination, P4 could not progress to encapsulation or understand that angles opposite corresponding sides should be equal.

In the rectangle activity, P4 created a similar rectangle with a 1/2 similarity ratio but struggled with coordinating ratio, proportion, division, and measurement, and although she created a rectangle with a 2/1 similarity ratio, she could not create rectangles with other similarity ratios and did not advance to encapsulating the concept of similarity.

Results and Discussion

The study observed that students constructed the concept of similarity effectively in a concrete manipulative (pantograph) supported environment, indicating durable learning due to prior knowledge associations. During the action stage, students used the pantograph to draw shapes at various scales and envisioned obtaining similar shapes. In the process stage, they realized that the interior angles of similar polygons remain constant, and similarity ratios occur only among sides with equal corresponding angles. By coordinating concepts like measurement, ratio, proportion, and angle, they encapsulated the idea that polygons are similar if their corresponding angles are equal, and their sides are proportional. This encapsulation led to the formation of the concept of similarity as a distinct entity when they applied various actions. However, with lower-intermediated struggled with the process and encapsulation stages Overall, the study suggests that participants constructed the concept of similarity according to the (pre)genetic analysis prepared, and the concrete manipulative supported environment positively contributed to this process.

The findings align with Özmen (2019), which indicated a significant difference in student attitudes from traditional teaching to concrete material methods. The results also align with Özdemir (2023) on the effectiveness of the ACE (Activity, Class Discussion, Practice) teaching cycle in the polygons and Çallık (2023) on activity-enhanced understanding of percentages according to APOS theory. Issues with material usage during the study support Yörük's (2018) findings on difficulties with instructional tools such as compasses, rulers, and protractors. The lack of readiness in concepts like ratio, proportion, and equal angles hindered concept formation, reinforcing Shahbari and Daher's (2020) emphasis on mathematical definitions for meaningful learning. General results support the notion that designing different teaching environments for equivalence and similarity can positively contribute to meaningful concept construction, as suggested by Yörük (2018), Uyen et al., (2021), and Shahbari and Daher (2020).

Recommendations

The pantograph significantly supports concept formation, especially during the action stage and internalization. Increased diversity in similarity ratios drawn by the pantograph is expected to further enhance conceptual internalization. Participants with insufficient prior knowledge of arithmetic and foundational concepts struggled with forming concepts. Hence, reviewing fundamental concepts before teaching similarity is crucial. It was observed demonstrating how to use concrete manipulatives before application is necessary. Also posing problem situations based on real-life contexts of student interest will be beneficial. It was observed that group work eliminates misconceptions through peer learning, aiding in accurate concept formation. APOS theory has been useful in

understanding this process, and further research could examine the use of various manipulatives.

References

Arnon, I., Cottrill, J., Dubinsky, E., Oktaç, A., Roa Fuentes, S., Trigueros, M., & Weller, K. (2014). *APOS theory: A framework for research and curriculum development in mathematics education*. Springer. https://doi.org/10.1007/978-1-4614-7966-6

Asiala, M., Brown, A., DeVries, D., Dubinsky, E., Mathews, D., & Thomas, K. (1996). A framework for research and curriculum development in undergraduate mathematics education. In J. Kaput, A. H. Schoenfeld, & E. Dubinsky (Eds.), *Research in collegiate mathematics education II* (pp. 1-32). American Mathematical Society. https://doi.org/10.1090/cbmath/006/01

Göçmen, B. (2022). *An investigation into knowledge of 8th secondary school students on congruence and similarity subjects* Master Thesis, Dokuz Eylül University, İzmir.

Carbonneau, K. J., Marley, S. C., & Selig, J. P. (2013). A meta-analysis of the efficacy of teaching mathematics with concrete manipulatives. *Journal of Educational Psychology*, *105*(2), 380. https://doi.org/10.1037/a0031084

Chihara, C. S. (1963). Mathematical discovery and concept formation. *The Philosophical Review*, *72*(1), 17-34. https://doi.org/10.2307/2183054

Çallık, H. (2023). *Examining of the teaching of 7th-grades percentages subjects with error based activities within the framework of the APOS theoretical*. Master Thesis, Atatürk University, Erzurum.

Çetin, H., Aydın, S., & Yazar, M. İ. (2019). Investigation of Attitudes and Needs of Manipulative Use of Middle School Mathematics Teachers. *OPUS International Journal of Society Researches*, *10*(17), 1179-1200. https://doi.org/10.26466/opus.525024

D'angelo, F., & Iliev, N. (2012). Teaching Mathematics to Young Children through the Use of Concrete and Virtual Manipulatives. Online Submission. http://files.eric.ed.gov/fulltext/ED534228.pdf

Dubinsky, E. (1991). Constructive aspects of reflective abstraction in advanced mathematics. In L. P. Steffe (Eds.), *Epistemological Foundations of Mathematical Experience* (pp. 160-202). Springer. https://doi.org/10.1007/978-1-4612-3178-3_9

Dubinsky, E., & McDonald, M. (2001). APOS: A constructivist theory of learning in undergraduate mathematics education. In D. Holton (Ed.), *The teaching and learning of mathematics at the university level: An ICMI study* (pp. 273-280). Kluwer.

Dubinsky, E., Weller, K., Mcdonald, M. A., & Brown, A. (2005). Some historical issues and paradoxes regarding the concept of infinity: An APOS-based analysis: Part 1. *Educational Studies in Mathematics*, *58*, 335-359. https://doi.org/10.1007/s10649-005-2531-z

Durmus, S., & Karakirik, E. (2006). Virtual Manipulatives in Mathematics Education: A Theoretical Framework. *Turkish Online Journal of Educational Technology-TOJET*, *5*(1), 117-123. https://doi.org/10.12973/ejmste/75332

Milli Eğitim Bakanlığı [MEB], (2018a). İlkokul ve Ortaokul Matematik Öğretim Programı (1-8.sınıf), Ankara.

Milli Eğitim Bakanlığı [MEB], (2018b). Ortaöğretim Matematik Dersi Öğretim Programı (9-12.sınıf), Ankara. https://doi.org/10.17522/balikesirnef.437843

Moyer, P. S. (2001). Are we having fun yet? How teachers use manipulatives to teach mathematics. *Educational Studies in Mathematics*, *47(*2), 175-197. https://doi.org/10.1023/A:1014596316942

National Council of Teachers of Mathematics [NCTM]. (2000*). Principles and standards for school mathematics*. Reston, Va. NCTM

Nishida, T. K. (2007). The use of manipulatives to support children's acquisition of abstract math concepts. *Dissertation Abstracts International: Section B. Sciences and Engineering*, *69*(1), 718.

Olkun, S. (2003). Comparing computer versus concrete manipulatives in learning 2D geometry. *Journal of Computers in Mathematics and Science Teaching*, *22*(1), 43–56. https://doi.org/10.1501/0000984

Özdemir, F. (2023). *The investigation of the effects of ACE instructional cycle on 7th-grade students' knowledge construction processes in subdomain of polygons within the framework of APOS Theory.* Doctoral Thesis, İnönü University, Malatya.

Özmen, G. (2019). *Effect of using concrete material and dynamic geometry software on 5th-grade students' achievement, attitude and spatial ability.* Master Thesis, Uşak University, Uşak.

Shahbari, J. A., & Daher, W. (2020). Learning congruent triangles through ethnomathematics: The case of students with difficulties in mathematics. *Applied Sciences*, *10*(14), 4950. https://doi.org/10.3390/app10144950

Skemp, R. (1987). *The psychology of learning mathematics*. Psychology Press.

Skiff, S. (1953). Concept formation and education. *Peabody Journal of Education, 30*(5), 296-299. https://doi.org/10.1080/01619565309536420

Suydam, M. N. (1986). Manipulative materials and achievement. *Arithmetic Teacher*, 33(6), 10-32. https://doi.org/10.5951/AT.33.6.0010

Toptaş, V. (2008). Geometri öğretiminde sınıfta yapılan etkinlikler ile öğretme-öğrenme sürecinin incelenmesi. *İlköğretim Online*, 7(1), 91-110.

Uyen, B. P., Tong, D. H., & Tram, N. T. B. (2021). Developing Mathematical Communication Skills for Students in Grade 8 in Teaching Congruent Triangle Topics. *European Journal of Educational Research*, *10*(3), 1287-1302. https://doi.org/10.12973/eu-jer.10.3.1287

Von Glasersfeld, E. (1991). Abstraction, re-presentation, and reflection: An interpretation of experience and Piaget‟s approach. *In Epistemological foundations of mathematical experience* (pp. 45-67). Springer. https://doi.org/10.1007/978-1-4612-3178-3_4

Yıldırım, A., & Şimşek, H. (2021). *Qualitative Research Methods in Social Sciences.* Seçkin Publishing.

Yilmaz, R. (2023). APOS Theory in Geometry Teaching. In R. Akkuş., Z. Toluk-Uçar., A. Duatepe-Paksu., B. Boz-Yaman & S. Bulut (Eds.), *Cognitive Processes in Geometry Teaching* (pp. 371-408). Vizetek Publishing.

Yörük, S. (2018). *The effect of 5E learning model-based activities on students: An action research.* Master Thesis, Osmangazi University, Eskişehir.